

Marine Regression and Palaeoenvironments During the Holocene in the Richardson River Basin, District of Mackenzie, N.W.T.

Régression marine et paléoenvironnements au cours de l'Holocène dans le bassin de la rivière Richardson, District de Mackenzie, T.-N.-O.

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Résumé de l'article

Nous avons effectué une étude détaillée d'une coupe stratigraphique de dépôts marins dans le bassin de la rivière Richardson, T.-N.-O. La séquence sédimentaire étudiée représente une régression marine dans un milieu estuarien. Elle débute par un faciès marin mis en place en eau peu profonde et évolue vers un faciès intertidal. Le retrait de la mer dans ce bassin a commencé avant 10 300 ans BP. Le relèvement isostatique terrestre est responsable de la régression marine graduelle jusqu'à son niveau actuel. Les sédiments marins contiennent 26 espèces d'ostracodes et 14 espèces de foraminifères; cette microfaune témoigne de conditions marines marginales d'eaux saumâtres résultant de la dilution de l'eau marine littorale par un apport d'eau douce des rivières drainant le bassin de la rivière Richardson.

Notes

MARINE REGRESSION AND PALAEOENVIRONMENTS DURING THE HOLOCENE IN THE RICHARDSON RIVER BASIN, DISTRICT OF MACKENZIE, N.W.T.

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ABSTRACT A detailed stratigraphic analysis was carried out on a river-bank section of late Quaternary marine sediments in the Richardson River Basin, N.W.T. The sedimentary sequence represents a gradual shallowing of the sea in an estuarine environment, from a relatively shallow marine facies to an intertidal environment. The withdrawal of the sea from the Richardson River Basin began prior to 10,300 years BP. Isostatic uplift caused the gradual regression of the sea to its present-day level. The marine sediments yielded 26 ostracode and 14 foraminifer species. Faunal evidence is indicative of brackish-water marginal marine conditions resulting from the dilution of nearshore marine waters by freshwater discharge from the many streams and rivers draining the basin of the Richardson River.

RÉSUMÉ Régression marine et paléoenvironnements au cours de l'Holocène dans le bassin de la rivière Richardson, District de Mackenzie, T.-N.-O. Nous avons effectué une étude détaillée d'une coupe stratigraphique de dépôts marins dans le bassin de la rivière Richardson, T.-N.-O. La séquence sédimentaire étudiée représente une régression marine dans un milieu estuarien. Elle débute par un faciès marin mis en place en eau peu profonde et évolue vers un faciès intertidal. Le retrait de la mer dans ce bassin a commencé avant 10 300 ans BP. Le relèvement isostatique terrestre est responsable de la régression marine graduelle jusqu'à son niveau actuel. Les sédiments marins contiennent 26 espèces d'ostracodes et 14 espèces de foraminifères; cette microfaune témoigne de conditions marines marginales d'eaux saumâtres résultant de la dilution de l'eau marine littorale par un apport d'eau douce des rivières drainant le bassin de la rivière Richardson.

INTRODUCTION

The purpose of this study is to investigate the stratigraphy, sedimentology and fauna of late Quaternary marine sediments in the Richardson River Basin, District of Mackenzie, N.W.T. (Fig. 1). Palaeoenvironmental conditions are also established by comparing the marine faunal assemblages to published data on late Quaternary marine assemblages, notably those of the Champlain Sea. However, such a comparison must be done with caution as regional differences undoubtedly affected the fauna between the two areas.

METHODOLOGY

About 25-100 g of sediment from each unit were washed through a 4.0 Ø mesh wire sieve and examined for microfossils. Ostracodes and foraminifer tests were handpicked from the sediment with the help of a binocular microscope and were identified by use of published references. The present material was collected from the study site (Fig. 1) by the author (KERR, 1984). These deposits are stratigraphically poorly known and their spatial distribution remains uncertain.

PREVIOUS WORK

A regional study of the north-central District of Mackenzie, N.W.T. by CRAIG (1960) was the first major endeavor to

elucidate the Quaternary history of this region. Evidence for a postglacial marine transgression was first discovered by Craig who postulated a marine limit at an altitude of approximately 100 m a.s.l. in the Richardson River Basin. This limit decreases in altitude towards the north and north-west due to the relatively less important isostatic rebound towards the north-west (BLAKE, 1970).

In the northern part of the Coppermine River Valley (Fig. 1), the maximum marine limit has been determined to be 170 m a.s.l. (ST-ONGE and BRUNEAU, 1982), based on evidence of deltas and raised beaches.

The recent study carried out by MERCIER (1983, 1984a, 1984b) in the Richardson River Basin indicates that the marine limit, based on the extent of reworked glacial drift surfaces, lies at approximately 170 m a.s.l.

STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS

The study of a river-bank exposure at approximately 25 m a.s.l. (Fig. 1) indicates that a variety of marine environments once existed in the Richardson River Basin. For the purpose of field research, the stratigraphic sequence has been subdivided into seven lithological units illustrated schematically in Figure 2. These units were sampled for granulometric anal-

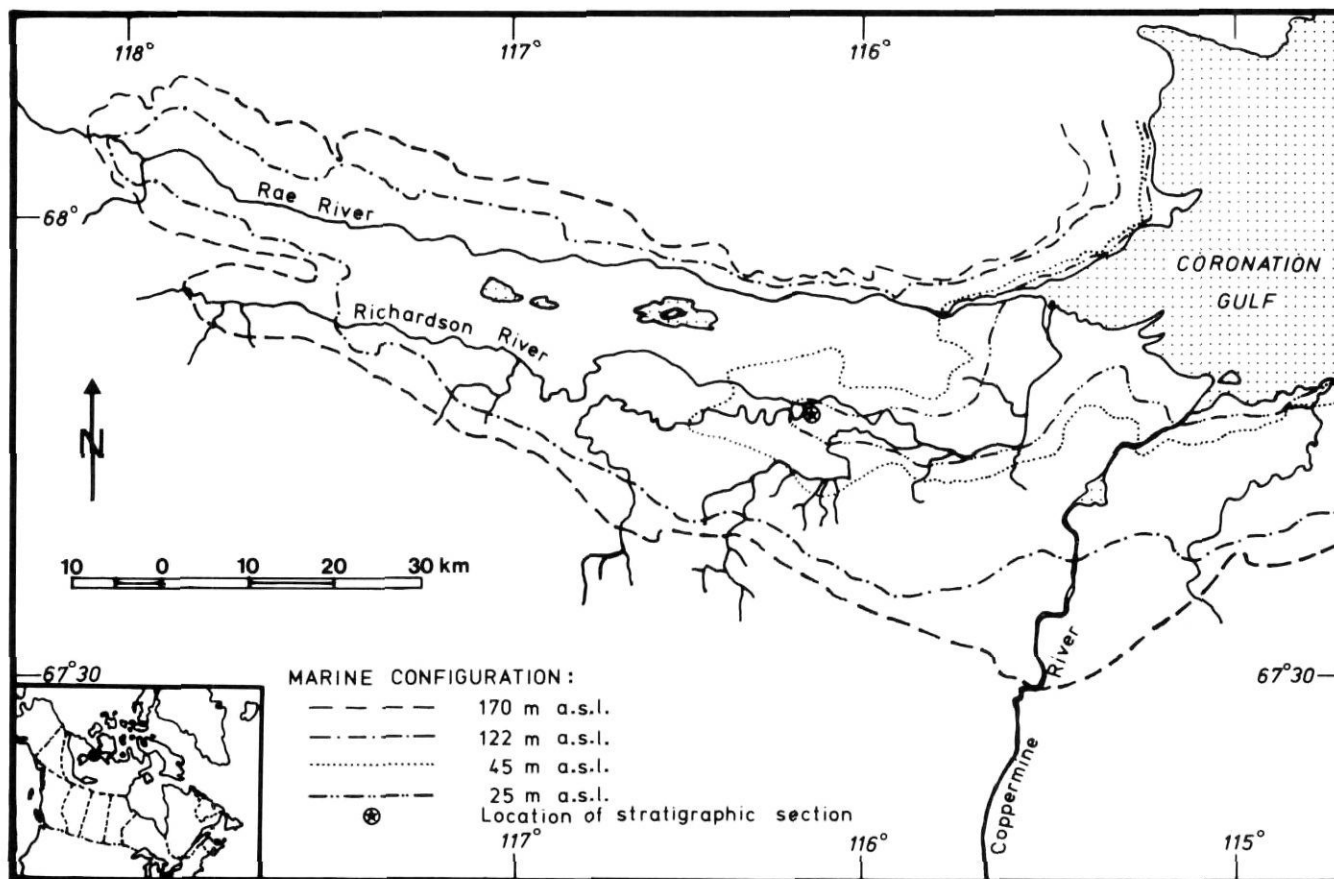


FIGURE 1. Palaeogeographic map showing marine limit and successive stages of marine regression in the Richardson River Basin.

Carte paléogéographique du bassin de la rivière Richardson, illustrant la limite marine et les différentes étapes du retrait de la mer.

ysis and examined for their micro and macrofossil contents. A synthesis of the characteristics and structures of each unit is also presented in Figure 2. The following is a brief discussion of the environmental conditions interpreted from this exposure.

Unit 1 is interpreted as being a relatively shallow water marine facies, which enabled silt to settle out of suspension in a tranquil environment. The differentiation of this unit into Subunits 1a, 1b and 1c is based on slight differences in grain size and fossil content. Nevertheless, the subunits remain genetically related, showing a general sedimentological continuity.

Unit 2 is marked by an increase in dispersed organic detritus including rare fossil terrestrial arthropods. Mottling is also a common phenomenon throughout this unit. The increase in sand content may suggest a growing continental influence, probably related to a prograding shoreline as a result of the lowering of sea level, hence indicating an increase in the fluvial contribution to these sediments.

Unit 3 is comprised of rhythmites which are made up of alternating layers of sand (Subunit 3a) and sandy silt (Subunit 3b). This difference in granulometry is responsible for a change in color between the alternating layers (Fig. 3). Although these layers retain their thickness laterally, they vary in thickness vertically from a few millimetres at the base of

Unit 3 to 10-15 cm near the middle and top of the unit. However, this trend in increasing thickness is not a continuous one, as thicker layers are interbedded with thinner ones (Fig. 3). Layers from both subunits have gradational upper and lower contacts, and appear to lack any type of internal sedimentary structures. Occurring in both subunits are deformational features which have been attributed to biogenic activity at the time of deposition. These bioturbation features, primarily in the form of burrows, are restricted to certain layers and are neither widespread nor particularly common.

The rhythmic deposition of Unit 3 is believed to be the result of variations in sedimentation due to seasonal discharge cycles. However, it remains to be determined whether the cycles of discharge and sedimentation occur in response to annual climatic cycles or to short-term weather changes within the annual cycle. Deposits similar to these found in Québec (HILLAIRE-MARCEL, 1979), are characteristic of shallow, isolated marginal marine basins in which they complete the marine sequence.

The basal part of Unit 4 is composed of rhythmites, similar to those in Unit 3. However, the differentiation of the individual alternating layers is less apparent because of their similarity in grain size. These rhythmites grade up vertically into lenticular, undulatory, followed by flaser bedding, as seen in Figure 4.

UNIT	THICKNESS (m)	SEDIMENTS	SEDIMENTARY STRUCTURES	ENVIRONMENTS OF DEPOSITION	GRANULOMETRY (weight %)	COLOR (After Munsell soil charts)
	0.6		Organic and eolian sediments			
7	0.7-1		Discontinuous laminations Small lenses	Post-marine fluvial sediments	Silt: 22 V.F. Sand: 66 M. Sand: 12	Brown 10 YR 5/3
6	0.8-1.1		Undulatory laminations Symmetrical wave ripples	Intertidal sediments	Silt: 20 V.F. Sand: 79 M. Sand: 1	Grayish brown 10 YR 5/2
5	0.3		Asymmetrical current ripples		Silt: 18 V.F. Sand: 70 M. Sand: 12	Light brownish gray 10 YR 6/2
4	1.3		Bifurcated flasers Asym. cur. ripp. Rhythmites	Shallow subtidal sediments	Silt: 97 V.F. Sand: 3	Light brownish gray 10 YR 6/2
3	1.1		Rhythmites Bioturbation	Seasonal rhythmites infilling basin	3a Silt: 37 V.F. Sand: 63 3b Silt: 95 V.F. Sand: 5	3a Gray 10 YR 5/1 3b Light brownish gray 10 YR 6/2
2	0.7		Massive	Shallowing upward marine environment	Silt: 78 V.F. Sand: 22	Grayish brown 10 YR 5/2
1c	0.9				Silt: 96 V.F. Sand: 4	Light gray 10 YR 7/2
1b	3.0		Faint bedding traces		Silt: 99 V.F. Sand: 1	Light gray 10 YR 7/2
1a	>3.7		Massive		Silt: 99.5 V.F. Sand: 0.5	Light gray 10 YR 7/2

LEGEND:



Silt



Plant detritus



Ripples



Sandy silt



Shells



Flasers



Sand



Peat lenses

FIGURE 2. Generalized stratigraphic section showing characteristic features and environmental relationships.

Coupe stratigraphique généralisée résumant les caractéristiques des unités et de leur milieu de dépôt.

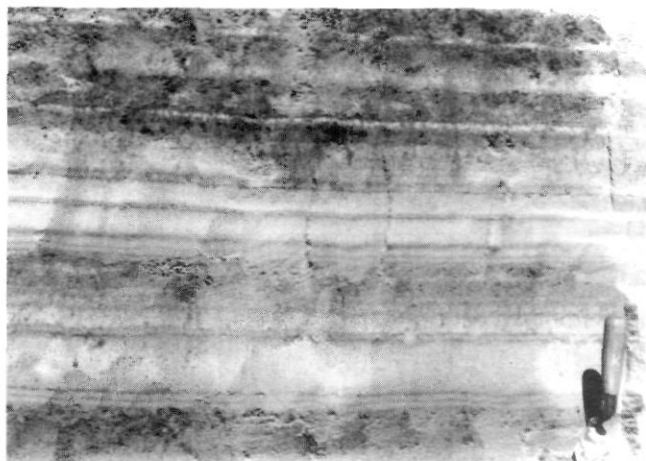


FIGURE 3. Rhythmites of Unit 3 (Subunit 3a = light gray, Subunit 3b = dark gray) and Unit 4 (scale = 18 cm).

Rythmites de l'unité 3 (sous-unité 3a = gris pâle, Sous-unité 3b = gris foncé) et de l'unité 4 (échelle = 18 cm).

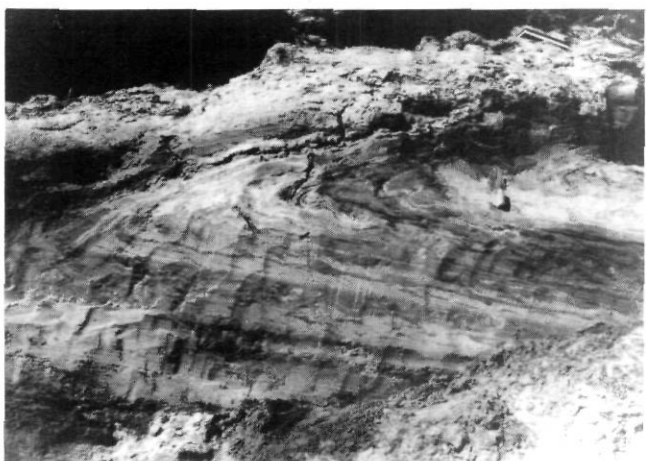


FIGURE 4. Lenticular, undulatory and flaser bedding, Unit 4. Note the folded nature of the sediments (scale = 25 cm).

Stratification lenticulaire, ondulée et évasée, unité 4. Remarquer la déformation des dépôts (échelle = 25 cm).

Asymmetrical current ripples associated with the undulatory or wavy bedding are overlain by bifurcated-wavy flaser bedding. Iron oxide aureoles were observed near the upper contact with Unit 5. This staining (Fig. 5) is believed to have originated from a point representing a ferruginous concretion. The genesis of these aureoles is possibly related to the radial migration of iron from a central nucleus (BERTOUILLE, 1976), often leaving the central zone stain-free. This particular succession of sedimentary structures, overlain by thinly interlayered sand/mud bedding, is characteristically found in tidal environments (REINECK and SINGH, 1980). It is the result of alternating periods of moving and slack water, formed in regimes influenced by tides or where the process of sediment supply is rhythmic or periodic (LEEDER, 1982).

The gradational upper and lower contacts of Unit 5 enclose a thin sequence of asymmetrical current ripples and lenticular



FIGURE 5. Iron oxide aureoles, Unit 4 (scale = 25 cm).

Auréoles d'oxyde de fer, unité 4 (échelle = 25 cm).

and undulatory laminations. The sediments are particularly rich in organic debris, containing an abundant and highly varied terrestrial fauna (KERR, 1984). Marine bivalves are most abundant in this unit, *Macoma balthica* being the dominant species. The sedimentary structures encountered suggest that this is a continuation of the previous sedimentary environment. Hence, it represents a tidal environment which is dominated by river influx as evidenced by plant macrofossils of terrestrial origin supplied by rivers.

In Unit 6, bedding structures include symmetrical wave ripples at the base of the unit which are overlain by undulatory laminations. Symmetrical wave ripples such as those appearing in Unit 6 are found on higher tidal flats (EVANS, 1965), thus marking the end of the depositional phase in the tidal environment.

Locally, Unit 6 together with Units 4 and 5, were subject to post-depositional deformation, as seen in Figure 4. The upturned, folded nature of these beds has been attributed to sea ice being driven up onto the shoreline, a common phenomenon occurring on Arctic beaches (HUME and SCHALK, 1964; DIONNE, 1978), although not necessarily restricted to Arctic environments.

In Unit 7, the absence of foraminifers and marine ostracodes and the presence of *in-situ* discontinuous peat horizons preclude a marine origin. Consequently, this unit is thought to represent a fluvial environment which prograded out onto the tidal flats shortly after the withdrawal of the sea. Such a sequence is in keeping with the concept of sea level lowering, as the intertidal zone is commonly a gradual transition from sea to land (JAMES, 1979). Unit 7 completes this succession of depositional environments where streams and rivers continue to supply sediments from continental areas. Peat from the base of this unit was dated at 1940 ± 80 BP (B.G.S. 912)¹.

Unit 7 is overlain by a 60 cm thick soil, i.e., a mixture of organics and eolian silt and very fine sand.

1. Brock University Geological Sciences Radiocarbon Laboratory, St. Catharines, Ontario.

ENVIRONMENTAL INTERPRETATION

The Richardson River Basin became ice-free with the eastward retreat of the Laurentide Ice Sheet. The isostatically depressed basin, together with extensive regions west of the ice front, were covered by Glacial Lake Richardson (MERCIER, 1984a). Eventually, as the ice continued to retreat east, marine waters entered the basin, permitting the waters of Glacial Lake Richardson to mix with the more saline marine waters. During this initial marine incursion which is thought to have been a relatively sudden and short-lived event (MERCIER, 1984b), the sea reached its maximum limit of inundation, at approximately 170 m a.s.l.

Two principal strandlines are observed in the Richardson River Basin: one at 170 m a.s.l., associated with deltas at the same altitude and a second at 122 m (Fig. 1), from which shells of *Macoma calcaria* have been dated at $10,300 \pm 240$ BP (GSC — 3663). A third has been estimated at about 45 m (Fig. 1), based on a detailed surficial geology investigation which revealed a sandy sub-littoral facies at this same altitude (MERCIER, 1984b). A fourth has been inferred at approximately 25 m (Fig. 1), based on the succession of sedimentary structures previously described and characteristically found in intertidal environments, although there is no visible surficial evidence for a strandline at this elevation.

Based on the sedimentary structures observed at the study site, a general regressional marine sequence is inferred. The silts at the base of the section (Units 1 and 2, Fig. 2) represent a relatively shallow water facies of approximately 20 m depth. Although all units are dominated by *Elphidium* species (Table I), the *Elphidium* sp. assemblage is characteristic of Units 1 and 2, in view of the relatively large number of specimens and the rarity of other species. The *Elphidium* sp. assemblage of Table I is comprised of a series of ubiquitous species indicative of cold, shallow waters of low salinities (CRONIN, 1976). This assemblage consists of the following species: *E. clavatum*, *E. incertum*, *E. incertum-clavatum*, *Protelphidium orbiculare* in addition to other *Elphidium* and *Protelphidium* species whose identification is tentative.

Similar observations have been noted by LAGOE (1979) who states that low diversity assemblages from shallow Alaskan waters are dominated by *E. clavatum*, *Elphidium* sp. and *Protelphidium orbiculare* which comprise 92% of the total fauna. These results are comparable to the present study where the *Elphidium* sp. complex encompasses more than 90% of the fauna in every unit (Table I). In addition to this, studies by BERGEN and O'NEIL (1979) in Alaska show that foraminiferal fauna dominated by *Elphidium* species are found at depths of less than 30 m, and that in the littoral zone, the genus *Elphidium* comprises 90% of the total population.

Faunas in which *Elphidium clavatum* is an overwhelmingly dominant constituent are typically restricted to relatively shallow, low salinity environments such as estuaries (LOEBLICH and TAPPAN, 1953; WALTON, 1964). They are characteristic of marginal marine conditions and usually inhabit water less than 10-20 m deep (BARTLETT and MOLINSKY, 1972). Bathymetric evidence for the 20 m depth estimate with regards to Units 1 and 2 is also based on the presence of genera

such as *Oolina*, *Lagena*, *Buccella* and *Guttulina* (Table I), which probably signify depths ranging from 20 to 40 m (CRONIN, 1976). Recent studies of estuarine foraminifera in England (MURRAY, 1968) show that *Quinqueloculina seminulum* and *Oolina melo* (Units 1 and 2, Table I) are marine forms which typically live in the open sea, but may be brought in an estuary by tidal currents.

According to FILLON and HUNT (1974), *Elphidium* species can tolerate salinities ranging from less than 18 ppt. to greater than 28 ppt., as they are found in modern oceans with salinity concentrations of 35 ppt. *Quinqueloculina seminulum* (Unit 1, Table I) is known to prefer salinities above 20 ppt.

There is no clear faunal succession in Units 3 to 6 (Table I) with respect to foraminifer, ostracode and bivalve species. However, this is not totally unexpected when one considers that the environment becomes progressively shallower as the marine regression occurs and that the initial depth (Unit 1) may have been no more than 20 m.

It is for this reason that these units are considered as a whole, thus enabling a general statement to be made, touching various aspects of the environment such as palaeosalinity and palaeotemperature. There are however exceptions to this (Units 4 and 5, Table I), but this will be discussed later.

Euryhaline and brackish-water ostracode species appear to dominate most units (Table I). They are found in all the marine sediments and show no preferred distribution within the section studied. *Eucytheridea punctillata*, *E. bradii* and *Heterocyprideis sorbyana* can tolerate salinities from 10 to 35 ppt. Furthermore, *Cytheromorpha fuscata* and certain *Cytherura* species (Units 2 and 5, Table I) are most commonly found in the intertidal zone to a depth of 10 m, frequently inhabiting brackish-water environments (WILLIAMS, 1969). *Acanthocythereis dunelmensis*, as well as *Cytheropteron montrosiense* and *C. paralatissimum* are less tolerant and are associated with saline waters of 29 to 35 ppt.

The freshwater ostracodes (Units 1 through 4, Table I) *Candona* sp. and *Ilyocypris gibba* are usually found in a wide range of environments, from ephemeral ponds and streams to lakes and rivers (BENSON, 1961). The presence of these species is not unexpected if one considers the geometry and extent of the sea within the Richardson River Basin at this time (45 m and 25 m levels, Fig. 1). In this estuarine environment, marine waters are likely to become brackish because of the continental run-off and freshwater influx by rivers and streams. Therefore, palaeosalinities were probably quite variable, as indicated by the mixed associations of fresh, brackish and marine water species.

Frigid to sub-frigid conditions appear to have persisted throughout the time of deposition; *Eucytheridea macrolaminata*, *Roundstonia globulifera*, *Cytheromorpha macchesneyi* and *C. pseudomontrosiense* (Units 1 to 4, Table I) are known to live in waters with a bottom-water temperature ranging from 0° to 10°C (CRONIN, 1977, 1981). Other ostracodes such as *Heterocyprideis sorbyana*, *Eucytheridea bradii*, *E. punctillata* and *Acanthocythereis dunelmensis*, whose annual temperature range is 0° to 15-20°C, are found in various units of the section (Table I).

TABLE I

Distribution of the micro and macrofauna

Species	Stratigraphic Units									
	1a	1b	1c	2	3a	3b	4	5	6	7
FORAMINIFERA										
<i>Elphidium</i> sp. assemblage	■	■	■	■	■	■	■	■	■	■
<i>Buccella frigida</i>	○			○			□	○	□	
<i>Polymorphina</i> sp.		○		□	□		○	□	□	
<i>Guttulina</i> sp.								□		
<i>Cassidulina</i> sp.				○						○
<i>Oolina melo</i>				○						
<i>Quinqueloculina</i> sp.			□		□					
<i>Q. seminulum</i>			○							
<i>Q. cf. stalker</i>	○									
<i>Lagena gracillima</i>			○	○		○				
<i>Spirillina</i> cf. <i>vivipara</i>							○	○		
Number of specimens	330	32	30	160	78	31	225	85	58	0
OSTRACODA										
Marine										
<i>Cytheropteron</i> sp.				○				⊙	○	
<i>C. montrosiense</i>				○						
<i>C. cf. inflatum</i>				○						
<i>C. cf. paralatissimum</i>	○						○			
<i>C. pseudomontrosiense</i>							●			
<i>Cytheromorpha</i> sp.				●	⊙	⊙				
<i>C. fuscata</i>				○						
<i>C. macchesneyi</i>				○		●				
<i>Eucytheridea</i> sp.	⊙	○		○			●	○		
<i>E. bradii</i>	●						●	●		
<i>E. cf. macrolaminata</i>	○									
<i>E. cf. punctillata</i>								○		
<i>Heterocyprideis</i> sp.			○							
<i>H. sorbyana</i>	○		○							
<i>H. cf. sorbyana</i>	○									
<i>Leptocythere</i> sp.				○						
cf. <i>Leptocythere</i> sp.								○		
<i>Acanthocythereis dunelmensis</i>								○		
<i>Cytherura</i> sp.								○		
<i>Roundstonia globulifera</i>	○									
Unidentified	○	○		●	●	⊙		⊙	○	
Non-marine										
<i>Ilyocypris</i> cf. <i>gibba</i>	○									
<i>Candona</i> sp.			○							
<i>C. subtriangulata</i>				●						
<i>Cyprinotus</i> sp.				○						
Unidentified	○			○	●	●	○			
Number of specimens	107	2	3	31	22	9	13	52	2	0
MACROFAUNA										
<i>Macoma balthica</i>	X	X	X	X			X	X		
<i>Mytilus edulis</i>		X					X	X		
<i>Mya truncata</i>							X			
Unidentified								X		
<i>Lunatia</i> sp.								X		
<i>Haminoea solitaria</i>	X		X				X			

Foraminifera

- rare < 1.0%
 □ common 1.0-10%
 ■ abundant 10-50%
 ■ dominant > 50%

Ostracoda

- rare 0-10%
 ● present 10-30%
 ⊙ common 30-75%
 ⊕ dominant > 75%

X- indicates presence
 of macrofauna

Foraminiferal evidence also suggests that bottom-water temperatures were at or below 0°C and rarely exceeded 10–12°C in the warmest summer months. This can be inferred from *Elphidium* dominated faunas of recent seas (LOEBLICH and TAPPAN, 1953), in particular from recent Arctic waters in which all foraminifera from Table I have been previously reported.

Based upon studies by LAMMENS (1967), it is also possible to infer palaeotemperatures up to 10°–12°C for marine waters, if only for a brief period of time during summer, since the pelagic larvae of *Macoma balthica* require such temperatures to survive.

The impoverished bivalve assemblage, consisting primarily of *Macoma balthica* and *Mytilus edulis* (Table I), also suggest that the environmental conditions were fairly rigorous. Although few pelecypods are found throughout the units, it is in Units 4 and 5 that their greatest concentration occurs (Table I), some in life position. These tidal and shallow subtidal deposits reflect environmental conditions which were tolerable only to a restricted fauna.

The most common species, *Macoma balthica*, is a ubiquitous species tolerant of a wide range of salinities: 4 to 35 ppt. (HILLAIRE-MARCEL, 1980). Consequently, this tolerance provides it with a considerable advantage over other species. Proximity to shorelines, more specifically intertidal to shallow subtidal habitats with sandy or silty substrates are the optimum conditions for its existence (LAMMENS, 1967).

Not unlike *M. balthica*, *Mytilus edulis* is also a relatively good palaeocoast indicator. It too prefers intertidal environments, living on sandy substrates. However, it is not as well adapted to brackish conditions as is *Macoma balthica*, which may account for its relative scarcity (HILLAIRE-MARCEL, 1980).

Mya truncata (Unit 4, Table I), typically an Arctic species, is known to inhabit hypersaline waters. Only two single valves were found in the entire section, suggesting that conditions were not particularly favorable to its existence in this area. The presence of the carnivorous gastropod *Haminoea solitaria* is not unexpected because numerous *Macoma balthica* valves show evidence of boreholes.

A comparison of the present study with investigations such as those by VILKS (1969) and LOEBLICH and TAPPAN (1953), notably with respect to benthic foraminifera, shows that many of the foraminifer species of the present study are rare in comparison with the observations made by VILKS (1969) in the middle Arctic. Shallow water faunas in the Canadian Arctic are dominated by agglutinated species (VILKS, 1969), whereas these species are extremely rare in the present study. Finally, the present study is characterized by a benthic foraminiferal fauna distinct in many ways from that of more open marine environments (LOEBLICH and TAPPAN, 1953).

CONCLUSION

The sedimentary succession described herein represents a relatively shallow marine facies grading gradually into a tidal environment, followed by a brief period of fluvial activity.

This interpretation is based primarily on characteristic sedimentary structures associated with intertidal zones, namely lenticular, undulatory and flaser bedding and their stratigraphic relationship with various sedimentary structures in other units. The tidal environment was significantly influenced by freshwater influx, a characteristic feature of estuarine deposits due to its position in the transition from marine to fluvial deposits in a regressive sequence.

The micro and macrofauna also served as alternate sources of evidence used to corroborate this interpretation. Seasonal changes in temperature, salinity fluctuations, extensive ice cover and turbulence in the littoral zone were major factors limiting the fauna to only species tolerant of dramatic changes in their habitat. For these reasons, the *Elphidium* dominated foraminiferal fauna, the ubiquitous ostracode species and the impoverished bivalve assemblage reflect the rigorous environmental conditions which existed in the shallow, Arctic environment of the Richardson River Basin.

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